GTT

Expert in LNG

Fuelling the future with LNG

© Roland Mouron / GTT

Safety | Excellence | Innovation | Teamwork | Transparency

© Roland Mouron / GTT

EDITO

© Dahmane

2018 was not a particularly good year for many energy sectors, however there is one that had a great 2018: Gas. In many countries, it appears that gas is the right solution for the energy transition: lower levels of pollution than coal and oil, less expensive than the latter and does not raise the same questions as nuclear power when it comes to investment and handling of waste. The swing towards gas is amazing: I remember the Gas Conference in Paris three years ago, when not even one politician made the choice to visit this great event attended by the world's gas leaders. Gas appeared to have a funny smell! Subsequently, however, the urgent problem of global warming, the difficulty in implementing any other solution, either renewable or nuclear, enabled gas emerge as the right solution.

The turnaround has been even more marked in the case of gas in its liquefied form (LNG). In 2017, all the experts agreed that there was far too much LNG. In 2018, there was not enough and new major investment decisions were taken to significantly increase its production. In its liquid form, gas is currently seen as the solution of choice to replace the highly pollutant fuels powering the ships of today. By the time the sulphur emission regulations come into force in 2020, we will almost certainly be seeing a real acceleration in the use of LNG as fuel in ships.

Energy issues are fundamental to the future of the planet. They will determine our future and must consequently be very carefully thought out, far removed from mere slogans, whims and posturing. Because gas is the least pollutant type of fossil energy, it will occupy a prime position in strategies for the reduction of our emissions in the coming decades, before totally carbon-free energy begins to take over.

Philippe Berterottière,
Chairman & CEO

© Roland Mouron / GTT

In 2018, the shipping industry has begun a cycle of regulations during which no less than ten MARPOL requirements are to be implemented, until 2020, under the aegis of the International Maritime Organization.
Those regulations affect vessels' efficiency (EEDI - Energy Efficiency Design Index) but also, of course, nitrogen and Sulphur oxides emissions through MARPOL annex VI rules.

I Making green propulsion a reality

The Global Sulphur Cap (0.5% mass by mass emissions, instead of 3.5%) will eventually take effect on January 1st 2020, implying technical improvements for a majority of the 70,000 ships concerned. Such a process, involving a technical change for the worldwide fleet, is merely a response to the longevity of vessels and their diesel engines: it would be too slow to only rely on better efficiency for new ships, as vessel turnover is so low. What are the options? Different technical solutions are already available to comply with the majority of the regulations ahead, **but the two choices are either retaining harmful fuels (and installing cleaning systems), or switching to cleaner ones**.

The economics of being environmentally friendly

Nevertheless, the decision between those solutions will still depend on each ship-owner and charterers' economics and strategy. Basically, it's a balance between Capital Expenditure (payed by the owner) and Operating expenses (fuel costs, most of the time payed by the charterer/operator). Three main solutions are currently considered, all of them implying more expense.

- Using low Sulphur fuel oil (LSHFO) is the most straightforward solution as it implies minor engine modifications, but the price of the fuel is substantially higher than current heavy fuel oil (HFO), which may not be economicaly sustainable in the long run.
- Exhaust gas cleaning systems (Scrubbers) allow owners to use the same fuel oil as today but implies important upfront investments; moreover these systems increase fuel consumption.
- Finally, vessels can switch to gas/LNG as a fuel. This solution also implies important upfront investments, but allows access to the cheapest and cleanest fuel available on the market, which is the most sustainable approach.

It is also an environmental decision, because not all of these solutions have the same environmental impact despite being compliant with the current regulations. Oil based solutions (LSHFO or HFO+Scrubbers) produces CO_2, Nitrous oxides and fine particles. Gas/LNG fuelled vessels emit no Sulphur, almost no Nitrogen, no particulates and less CO_2 than oil based solutions.

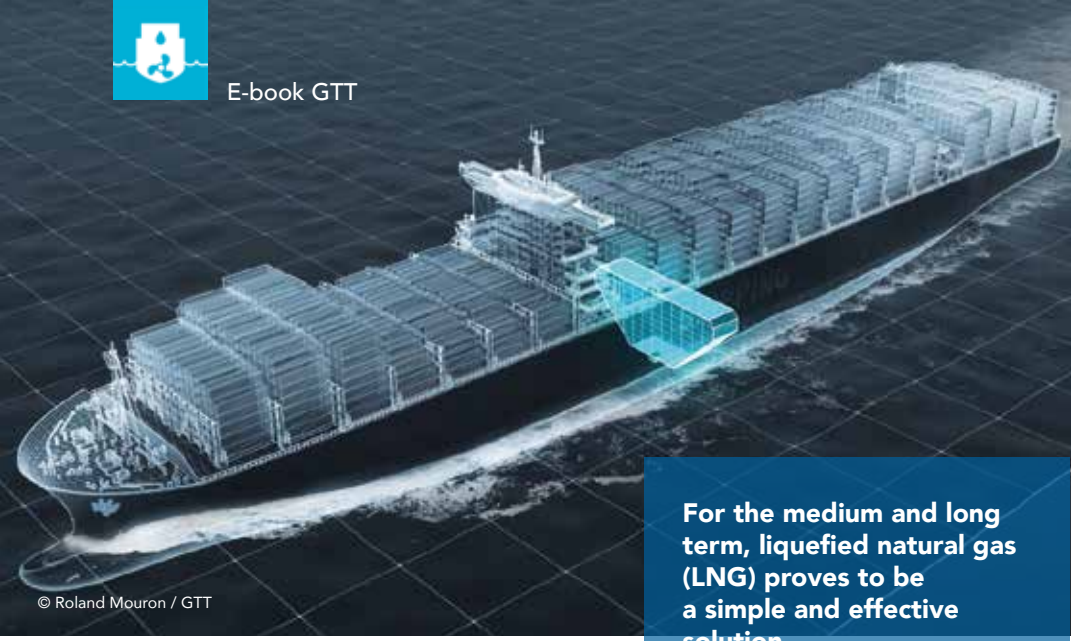
Moreover, the scrubber concept is to wash exhaust gas, most of them with seawater which is discharged into the sea afterwards.

To accommodate change, the shipping companies will therefore have different options.

II The industry choice

Old and illusory solutions

- **First, if a company retains classical fuels**, there will remain uncertainties such as fuel quality and requirements for blending. The supply will be unpredictable, and different categories of fuel will not be mixable in the same tanks, due to a paraffin deposit. A steel work will be necessary on-board the ships to separate capacities and multiply the supply system, as well as more piping towardsthe engine room.
  In addition, there is no standard for the new 0.5% LSFO that has been agreed at international level.
- **These doubts could favour the scrubber option**, consisting in cleaning the exhaust gases with an open loop device. But this solution also has its drawbacks. The equipment requires energy, about 180 – 240 kW for a scrubber sized to treat the exhausts from 10 MW engine, and will impair the Energy Efficiency Design Index (EEDI) of the ships. The future regulations could also make scrubbers less relevant, for example the phase 3 of EEDI, likely to enter in force by 2022 alongside the recent IMO target discussed during the MEPC72 to reduce all shipping Greenhouse Gas (GHG) emissions by 50% in 2050. The pollution retained in a scrubber is released at sea through wash water, instead of classical combustion fumes, which is like sweeping dust under a rug.
- **At the other end of the spectrum, zero emission propulsion technologies are still not expected to be economically attractive in the coming decades.** Still at research and experimental levels, full electric propulsion or sails will moreover require completely different ship structures. These options do not relate to the current world shipping fleet.



© Roland Mouron / GTT

For the medium and long term, liquefied natural gas (LNG) proves to be a simple and effective solution.

© Ponant

A breakthrough, efficient technology that convinces the industry: LNG

"Gas is not a silver-bullet, but it is a step in the right direction when it comes to reducing carbon emissions," says Mark Bell of the Society for Gas as a Marine Fuel (SGMF). At an environmental level, LNG's usefulness is undisputable: it emits no Sulphur oxides, no particulate matter and low Nitrous oxides, up to 90% less than HSFO. With its higher calorific value, fuel consumption is also down by more than 20%.

According to MAN B&W, a 52 MW M-type, Electronically Controlled, Gas Injection (MEGI) ship will consume about 0.17kg/kWh on Marine gas oil, and 0.13 kg/kWh on LNG mode.

This efficiency is certainly the reason why the world's third largest container liner operator **CMA CGM** has recently chosen GTT technology for its new flagships. Nine 22,000 TEU vessels, the largest ever containerships, have been ordered and are to be equipped with dual fuel propulsion engines X92DF engines by Winterthur Gas & Diesel Ltd. A single LNG tank will feed the main engine as auxiliaries. With a capacity of 18,600 m³, it will allow the ships to make the full Europe-Asia roundtrip, with one bunkering operation in northern Europe. A dedicated supply chain is being developed: Mitsui O.S.K. Lines (MOL) has ordered a bunker ship, with a capacity of 18,600 m³, to be chartered by TOTAL who will supply LNG to CMA CGM.

Passenger ships can also gain from switching to LNG, as the GTT fuel tank solution gives more space for commercial use – saving cabins - and more autonomy due to its compactness, adaptable geometry and its high useful volume ratio. GTT membrane can now also operate at higher pressure than traditional tanks, thereby enabling an easier management of boil-off for small tank volumes. **The PONANT icebreaker expedition ship** will receive two GTT LNG fuel tanks (total capacity of 4,500 m³), which means that trips from two weeks to one month can be made entirely using LNG.

The number of LNG bunkering vessels is rapidly growing, from one at the beginning of 2017 to six in early 2018. According to Peter Keller, chairman of TOTE, another ship-owner who has opted for LNG, "the bulk LNG infrastructure is largely built, what remains is the last mile, in which the industry is showing a growing appetite to invest". An appeal based on cost-effectiveness: several of the main shipping stakeholders have already made the choice to help the development of LNG as a commodity fuel. And as for all disruptive technologies, the early birds catch the worm.

© Conrad

Gaztransport & Technigaz, better known as GTT, is a frontrunner in the development of containment systems for the shipping and storage of LNG in cryogenic conditions. GTT offers engineering, consultancy, training, maintenance support and technical design services.

© Conrad

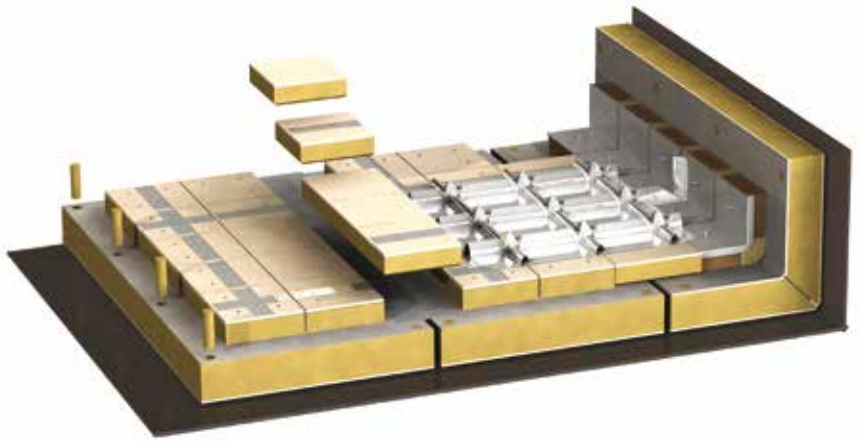
III GTT a frontrunner

GTT's experience over several decades has brought the company through multiple changes in technology and in the market.

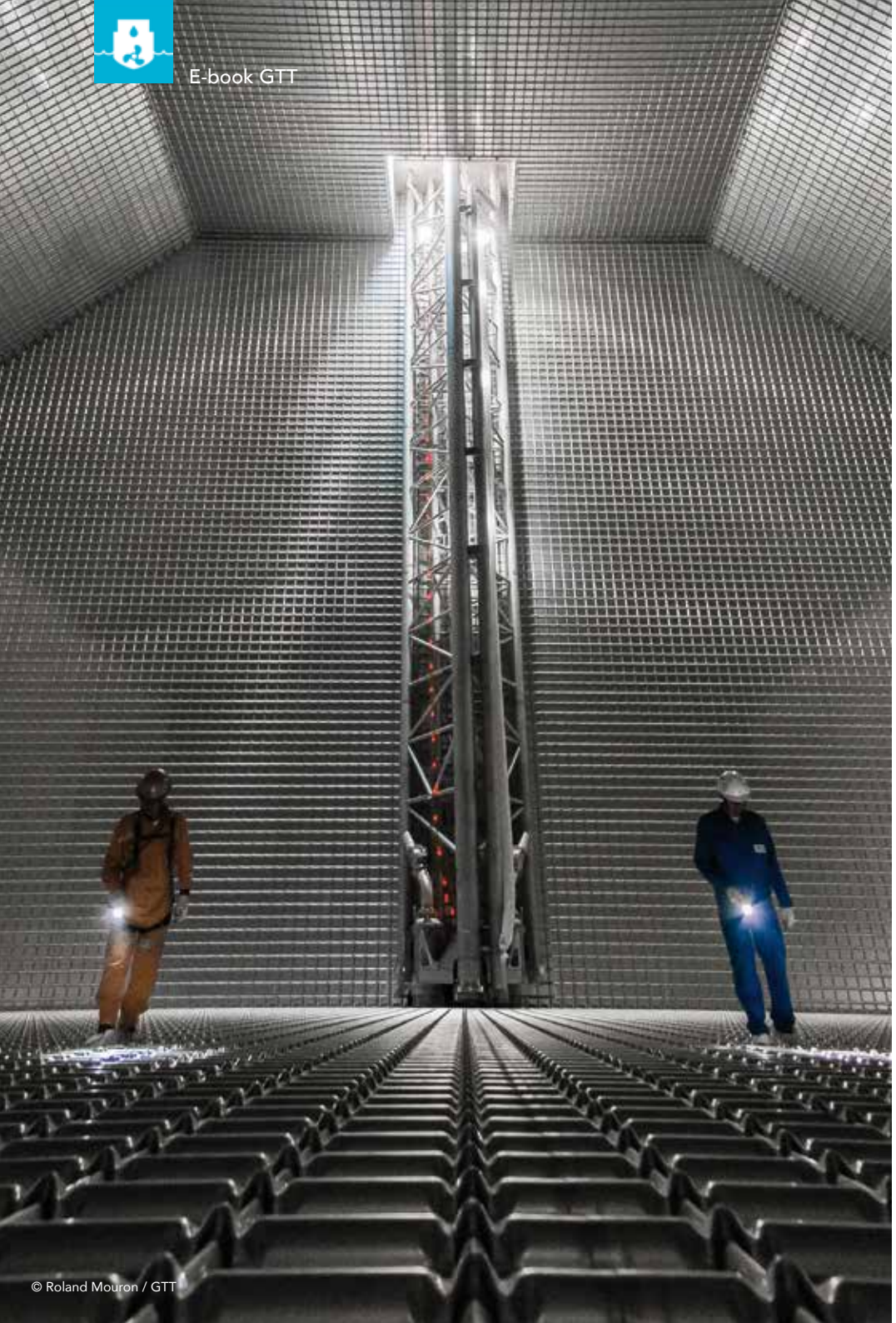
For example, GTT has lately developed new versions of its Mark III and NO96 systems "which allow operation with no lost boil-off at lower speeds, thereby increasing the vessel's operational flexibility" as commercial Vice-President David Colson underlines. But on the long term, GTT's products still pursue two major goals: safety and cost-effectiveness.

The Mark III system and its evolution

The original Mark III membrane tank design has a characteristic waffled stainless steel primary barrier. It has been recently further developed, with the recent introduction of the Mark III Flex and Mark III Flex+ versions. The latter has reached **a guaranteed daily natural boil-off rate (BOR) of 0.07% of the tank volume**, a spectacular result obtained by increasing the insulation thickness to 480mm (+80mm compared to Mark III Flex). A secondary barrier has also been developed, with a supplementary layer of rigid triplex, resisting more thermal and mechanical loads. The Mark III membrane family has been fitted in over 150 LNG carriers around the world, and boasts an excellent track record.



Mark III Technology



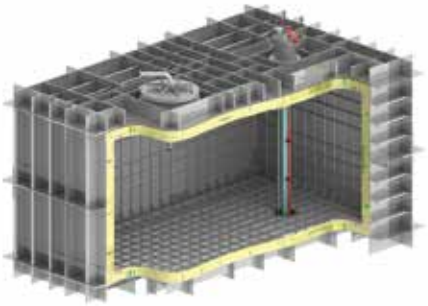
The NO96 versions

GTT also offers its long-serving NO96 membrane design, with its distinctive low-distension Invar® 36% nickel steel primary and secondary barriers.
It has also been further developed for improved thermal performance: the product line is now augmented by four other versions, NO96 GW, NO96 L03, NO96 L03+ and NO96 Flex.

- With NO96 GW, the insulation between the two metallic barriers is made by glass-wool.
- For NO96 L03, this secondary insulation is a box bearing glass-wool and assembled from plywood and reinforced polyurethane foam.
- For NO96 L03+, both secondary layers are made up of plywood and polyurethane foam. This version offers the best cargo boil-off rate, with only 0.1% loss of the tank volume per day.
- NO96 Flex maintains the main elements of the NO96 technology which have become key factors in its success. The insulating panels are mechanically anchored to the inner hull. The double metallic barrier concept remains with an unchanged secondary Invar® membrane but with an evolution of the primary membrane which is changed from Invar® to corrugated stainless steel.

The LNG Brick®, ready to be integrated

GTT's most recent product is dedicated to ships requiring less than 3,000 m³ of LNG. The LNG Brick® is based on the Mark III membrane, with slight modifications, but comes as a cubic tank that can adapt to many vessels arrangement, with full flexibility on length, breadth and height. LNG Brick® also includes the gas preparation room. It can be constructed at the specialised promises of GTT licensees, and delivered at the shipyard, ready to be installed. Typically, it will be an LNG bunker tank option for an LNG-powered ship. All of this enables small or medium-sized shipyards, that lacks personnel familiar with LNG and membrane technology, to access the construction of LNG-fuelled ships.



LNG Brick® Technology

IV GTT's goal: the best service

Continuous R&D

This efficient product line does not mean that GTT can stop developing new solutions or scientific research: one quarter of our employees work in research and development.

"GTT has to be the lead expert in matters dealing with cargo containment and BOR, and proactive in finding optimum solutions" states D. Colson.

For more than two years, the company has been partnering with Airbus on R&D topics, to increase GTT knowledge of gas boil-off and pressure rise phenomena during a vessel's lifecycle. "**We believe we are among the few actors in the industry that have reached this level of understanding concerning LNG behaviour in marine applications.**" says D. Colson.

"This knowledge enables us to perform studies for a wide variety of owners to advise them on the optimum choices", adds D. Colson.

For example, the increase in strength for GTT membrane tank containment systems permit the use of GTT products in harsher sea conditions for specific projects. In the rapidly evolving LNG shipping sector, the company manages to extend its competitive edge, for the benefit of its clients, as GTT always targets operational benefits coupled with competitive pricing for its products.

How it's done: shipyard and engine builder requirements

Of course, offering the best technical solution implies a deep understanding of GTT client vessel operational profiles, as well as the performance of the ship propulsion and cargo-handling system packages. That is why **GTT is used to working with key stakeholders**, including ship-owners, shipyards, engine manufacturers and designers of Fuel Gas Supply Systems (FGSS) and reliquefaction systems. The challenge is to reach sufficient integration between the various systems, to avoid complexity and risk.

> **All in all, our technical knowledge, our overall packages and all of our work have a priority: to facilitate our client decision process to switch to LNG as fuel, to thereby obtain the maximum benefit.**
>
> **Julien Bec - Vice-President, LNG as Fuel Division at GTT**

GTT partnerships maximise efficiency

In order to offer a comprehensive LNG solution package, GTT has concluded strategic partnerships with Wärtsilä Gas Solutions and Daewoo Shipbuilding and Engineering Co Ltd (DSEC) in December 2017.

GTT's partnership with **Wärtsilä** provides customers with a one stop shop solution, an optimised LNG storage capacity, reduced project risks, savings for project interface management and full services in operation. Through the companies' combined fields of expertise, both in storage and fuel gas handling systems, a single unified lifecycle proposal from design to optimisation in operation is possible.

Throughout several decades of building experience with GTT's membrane tank technologies, **DSEC** has become a key membrane tank outfitter fully capable of incorporating cargo handling systems within an integrated "tank and gas system" package.

The commitment of the shipping industry towards LNG testified by the ordered membrane technology-based LNG fuelled container vessels, cruise ship, an LNG Bunker ship, is yet to reach a tipping-point. **GTT and its partners are expecting to repeat such optimised concepts in other areas**: Crude/product tankers, Bulk carriers, Pure Car & Truck Carriers, as well as Offshore support vessels.

In the meantime, GTT also develops partnerships which enable external companies to be certified as licensed outfitters (installer subcontractor) and therefore use GTT's technologies to design optimised ships in terms of capacity, size and draught.

These partnerships have **the ambition to provide clients with a broader range of LNG solutions** by enabling other companies to push LNG distribution into markets where there is currently a large requirement for cleaner, more efficient and lower cost energy sources compliant with the upcoming IMO 2020 regulations.

Those tailor-made partnerships are concluded by the signing of a **Technical Assistance and License Agreement Outfitter** (TALAO) following a successful completion of GTT's rigorous qualification program which includes staff training.

The company has to prove its ability to build membrane containment systems to the highest international standards. Companies such as Gabadi, DSEC, Endel and AG&P are already certified as licensed outfitters.

Excellent partnerships make successful projects.

LNG
THE MARINE FUEL OF THE FUTURE

AN ENVIRONMENTALLY FRIENDLY SOLUTION

95% reduction in fin particle emissions

Over **99%** reduction in Sulphur (SOx), emissions, compliant with the IMO 2020 regulation

80% reduction in nitrous oxyde (NOx) emissions

20% reduction in CO_2 emissions

LNG PRODUCTION CHAIN

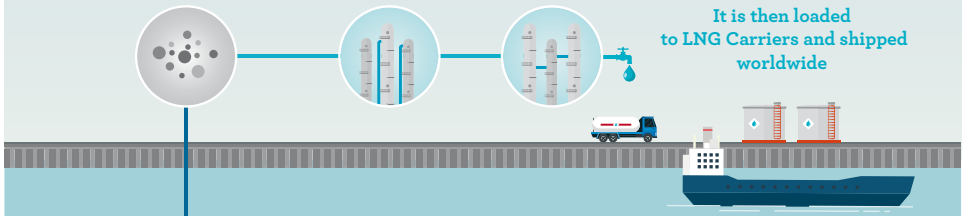
① The natural gas is extracted from the gas field, and then piped from the platform to the liquefaction plant

② The gas is treated and purified

③ It is then liquefied at c. -160°C

④ As a result, the natural gas volume is divided by 600, which allows an optimal transportation.

It is then loaded to LNG Carriers and shipped worldwide



AN ECONOMIC SOLUTION

In the long run, more economic than ultra-low sulphur fuels (MGO, MDO)

Reduced maintenance and operational costs

GTT Expert in LNG

LNG
THE MARINE FUEL OF THE FUTURE

A GROWING MARKET AROUND A WELL KNOWN TECHNOLOGY

A PROVEN TECHNOLOGY IN LNG CARRIERS

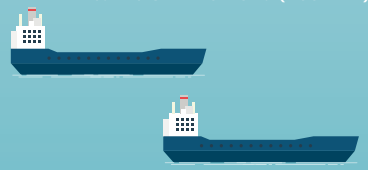
1964 First LNG carriers

1969 **2** first large capacity LNG carriers (71,5K m³)

1997 **5** LNG-fuelled vessels

ADOPTED BY AN INCREASING NUMBER OF SHIP-OWNERS FOR THEIR SHIP'S PROPULSION

2008 Delivery of the largest LNG carriers in the world (266K m³)



2014 **100*** LNG-fuelled vessels

2017 GTT receives order notification for the tanks of **9** container ships

2018 2019 GTT receives order notification for the tanks of:

- **2** bunker ships
- **1** ice-breaker cruise ship
- **1** container ship (retrofit)

450 LNG carriers in operation

45,000 deliveries of LNG by LNG carriers worldwide

265* LNG-fuelled vessels

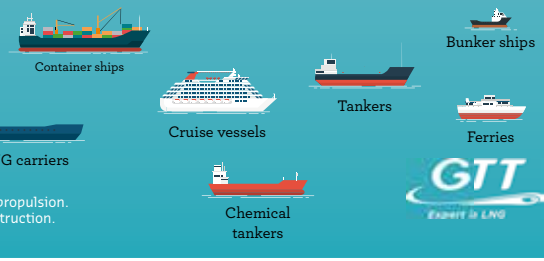
Global merchant fleet of **94,000** vessels which could adopt LNG as fuel

ABOUT GTT

1963: Creation of Technigaz

1965: Creation of Gaztransport

1994: Birth of GTT, outcome of the merger of Technigaz and Gaztransport



The LNG Carriers use a part of their LNG cargo for propulsion.
* Figures include in-service and vessels under construction.

GTT Expert in LNG

Sources

SEARCHING FOR SOLUTIONS (From LNG INDUSTRY)

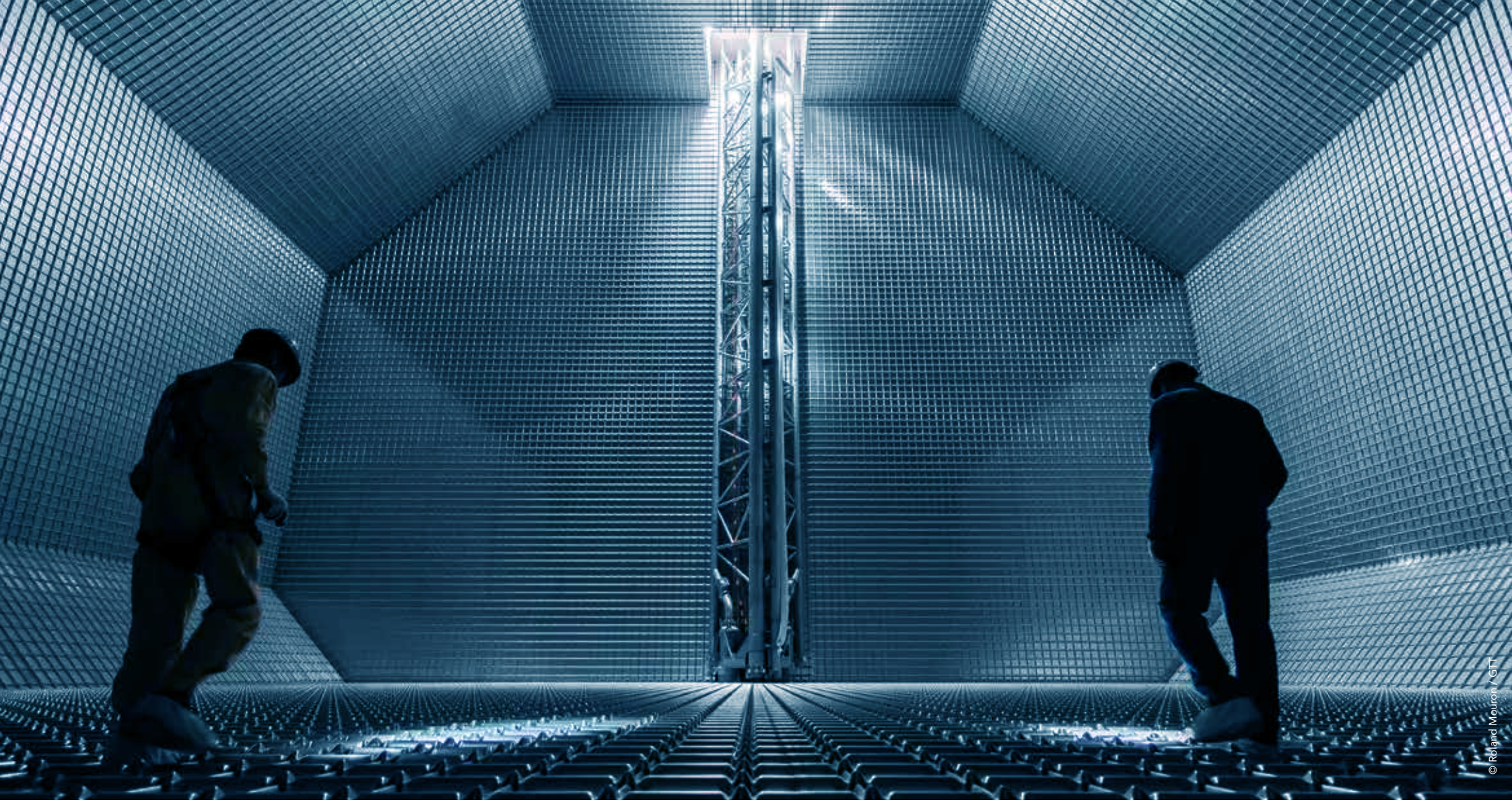
Geoffroy Beutter, GTT, France, states the case for the GTT membrane tank as the preferred solution for LNG fuelled ships in light of looming emissions legislation.

BRICK BY BRICK (From LNG INDUSTRY)

Guillaume Gelin, GTT, France, discusses how membrane technology can be competitive for small capacities.

THE MARCH OF THE GTT MEMBRANE (From LNG World Shipping)

GTT has been developing its established Mark III and NO96 membrane tank technologies to accommodate the changes sweeping through the LNG shipping industry.



© Roland Mouron / GTT

GTT designs and provides technologies which combine operational efficiency and safety, to equip LNG carriers, floating terminals, and multi-gas carriers. The company also develops solutions dedicated to land storage and to the use of LNG as fuel for the vessel propulsion, as well as a full range of services. More information on **www.gtt.fr**

GTT
Expert in LNG

GTT SA (Head Office)
1, route de Versailles
78470 Saint-Rémy-lès-Chevreuse
France
+33 (0)1 30 23 47 89
commercial@gtt.fr

GTT (Gaztransport & Technigaz) SA au capital de 370 783,57 €
RCS Versailles B 662 001 403

www.gtt.fr

Safety | Excellence | Innovation | Teamwork | Transparency

aressy.com - 05/19 - 406